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ABSTRACT

Three procedures are examined that educational researchers can use to analyze quantitatively the extent to which modifications of specific teacher behaviors lead to changes in student achievement. The task requires decent descriptions of the behaviors, appropriate statistical tools and measures of student outcomes that are worth while examining. The data, collected in the course of an evaluation of the relationship between the organizational structure of schools and student achievement, is not entirely appropriate for the issues dealt with here. Therefore, paths are suggested that this research might take in the future: (1) it is possible, using multiple regression analysis, to construct models of teacher behavior that reflect the view that some set of teacher behaviors affect student outcomes, and (2) these models can be applied at least three distinct ways, depending on the kinds of assumptions that one is willing to make about the data and the kinds of questions that one wishes to address. (Author/RC)

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TOWARDS A MODEL OF TEACHER BEHAVIOR AND STUDENT ACHIEVEMENT

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I. Introduction

In this paper we will examine three procedures that educational researchers can use to analyze quantitatively the extent to which modifications of specific teacher behaviors lead to changes in pupil achievement. This is not a simple task. It requires decent descriptions of the behaviors, appropriate statistical tools and measures of student outcomes that are worthwhile examining. Our data, collected in the course of an evaluation of the relationship between the organizational structure of schools and student achievement, is not entirely appropriate for the issues we wish to deal with in this paper. Therefore we can only suggest paths that this research might take in the future.

Our major arguments are as follows:

1. It is possible, using multiple regression analysis, to construct models of teacher behavior that reflect the view that some set of teacher behaviors affect student outcomes.

2. These models can be applied at least three distinct ways, depending on the kinds of assumptions that one is willing to make about the data and the kinds of questions that one wishes to address.

Following a brief description of the sample and measurement instruments we will examine each of these issues in turn.

II. Procedure

a) The Sample

The schools participating in our study are located in a suburban community. The school district is racially mixed (approximately 11% black) and represents a range of socio-economic backgrounds. As a consequence of

de facto segregation, most of the schools are fairly homogeneous on both racial and social class indices.

A sample of 14 fifth grade classrooms was chosen from seven of the elementary schools in the district. The classes were selected to represent both a variety of social class backgrounds and the spectrum of classroom organizational styles. Questionnaires were administered to the students in these rooms on three occasions. The data for the analysis of student outcomes in year one is taken from the first two administrations of the questionnaires, September, 1971, and May, 1972. The analysis of the second year data uses the test scores collected in May, 1972, as pre-test measures and those collected in May, 1973, as post-test scores.

As with most longitudinal studies there was some attrition due to students moving out of the district, illness, etc. Our final sample (N=187) included only those students for whom there was complete data on all variables. Several equations were run with less stringent requirements, but they do not differ in any significant way from those reported in this paper.

b) The Measures[1]

i. Achievement

The achievement measure selected for use in this study was math. The arithmetic scale consists of 36 items from the CTBS tests of Computation, Concepts and Applications.

ii. Affective Outcomes

The current trend in the educational literature is to attend not only to the strictly cognitive outcomes of schooling, but to also consider

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[1]Other measures of cognitive and affective development were collected for use in the original study. They are not included in the present analysis.

outcomes that are more appropriately considered affective.

A measure of satisfaction with school, adapted from Hoyfjeldstil and Locke's (1952) Index of Job Satisfaction, was administered to these students. With appropriate modifications in the wording of the items, 8 of the original 18 items were included in the final scale. The others were omitted because of low factor loadings and/or the difficulty of reworking the item from one context to another. A factor analysis indicated that these eight items loaded on a single factor.

iii. Teacher Behavior

A questionnaire, adapted from Schutz's (1960) Children's Reports of Parent Behavior Inventory, was administered to the students to measure their perceptions of their teacher's behavior.[1] The adaptations consisted of deleting items that did not pertain to a classroom setting and changing the word "parent" to "teacher" in those items that were appropriate. ... Following a factor analysis of the first round of data, 34 items were considered for inclusion in the remaining administration of the scale. Thirty of these items loaded on two factors that we call Caring (Criterion Ref. R Hoyt, 1967, Diff.) and Control. The remaining four items constituted a third factor, Freedom or Autonomy. On the assumption that students would manifest some bias in drawing stable perceptions of their teacher's behavior, T-Bar scores of teacher behavior are derived from the May, 1972, administration of the Schutz scale just as and the May, 1971, administration for pretest use. Individual perceptions of teacher behavior were averaged over all the students in a room; the resulting measure was used as a description of behavior for that room.

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[1]In addition, student observers were trained in the use of Ryans's (1960) schedule of teacher behavior. The observational data is not included in this analysis.

[illegible] reports on the validity and reliability of the original scale, as well as the multiple, the reasonably extensive [illegible] have at least minimal estimates of reliability and construct validity. The modifications are comparable to those presented in other studies that have used factor analysis as a means of validating instruments (e.g., Travers, 1964).

VII. [illegible] on Sponsor and Peers

In general, theories about teacher effects index their teacher behavior effects the academic performance of students. Some data were gathered that, as that what the appropriate level of whether or not (or to what extent) teacher behavior does affect children is to consider a social level analysis. Individual student background measures are examined to see[illegible] with aggregate measures of the classroom environment (teacher behavior) in the production of individual student outcomes.

Researchers refer to the problem related to changing levels of analysis as problems of aggregation (when individuals or groups are lumped together) and disaggregation (when they are separated). In sociology, the general treatment of the problem appears to be [illegible]'s (1950) paper on "Ecological Correlations and the Behavior of Individuals." The authors of the [illegible] "Handling of Theoretical Assumptions" do not deal directly with the level of analysis issue. The design of their study, however, [illegible] an awareness of the need to explore multi-level models in the analysis of the schooling process. Coleman et al refer to the design as a "two level" regression analysis. It [illegible] an [illegible] treatment of the problem in the education literature, as are fairly certain that the particular methodological issue [illegible] and after a large part in the design and supervising of studies of teacher

criterion.

The appropriate model, thus, should describe such more than mere [illegible] changes. It should show in which the effects of various [illegible] on student behavior as individual student outcomes while at the same time ascertaining the characteristics of the individual student. To do this requires a modeling technique capable of handling individual and classroom level variables simultaneously. Hierarchical analysis, which is the most general form of the analysis of variance or commonly used in educational research, meets these specifications.

There are good reasons for researchers to be concerned with the role of teachers [illegible] particularly the level of expectation as the "target" side of the equation. First, multi-level analyses of the effecting process correspond to a [illegible] appreciation of what the classroom teaching process is all about. Second, no study can [illegible] areas in the entire instructional process.

To illustrate the latter point let me [illegible] in Rosenshine and Furst (1973), "Research on Teacher Performance Criteria." In their attempt to synthesize some of the research on teacher effectiveness, the authors utilize the [illegible] "process-product" studies to describe "[illegible] which change or affect observed teacher behaviors or student outcome measures." Three studies are [illegible] as samples.

The [illegible] studies cited by Rosenshine and Furst appear to be based on [illegible] means. A teacher behavior is noted, some [illegible] training is compared, and correlations between the teacher behavior and [illegible] learning are calculated over a sample of classrooms. The conclusions [illegible] are to correspond to the amount of variance in "good" learning

associated with variance in teacher behavior, a coefficient of .20 between teacher clarity and mean pupil achievement, although this .20 ($.20^2$) of the total mean variance in student achievement is attributable to teacher clarity. However, if only 5% of the variance between students is accounted for by this .20 ($.05 \times .20$) of the variance in individual achievement is attributable to teacher clarity. In mathematical terms, the difference would drop from .20 to .01 ($.20^2$ - $.05^2$) by changing from mean to variance as the unit of analysis. Unfortunately significant as any such interventions would probably not be regarded as important by practitioners faced with the cost of improving the talent of individual teachers. This example brings clearly to the mind of analysts this effect the value of correlations between environmental variables and student outcomes, usually resulting in underestimates of the size of environmental effects.

V. Uses of regression analysis

The choice of regression analysis that our colleague Jacobs has contemplated raises questions in applying science behaviors. In Volume XXVII, also in his previous term paper, "Comparison of the social sciences through history analysis," there are at least three different ways to study the techniques can be used.

Volume reviews the various approaches, with particular emphasis on the conclusions that authors draw can. Briefly, these include the use of regression analysis (1) to determine the effectiveness of different (2) with specified goals with human characteristics, (3) as a technique for examining the causal relationship in a set of variables that some prior knowledge can be used about the causal structure among them (path analysis), and (4) as

Model 2.1 (Table II), with all of the variables included, accounts for approximately 73% of the variance in math achievement. A comparison of model 2.2 with model 2.1 indicates that only 6.2% of the total variance can be attributed to differences between rooms over and above differences associated with student background characteristics. Indeed, under ideal circumstances, where student background can be assumed to be unrelated to room assignment, only 15% (model 2.3) of the variance in student achievement is associated with any differences between rooms.

Fifteen percent isn't much, six percent is even less--but these figures look like other estimates of the amount of variance in achievement that lies between school units. And, their size is NOT a function of inadequate measures of teacher behavior.

Finally, we note that about 58% of the variance in student achievement is associated with the student background measures, over and above differences between rooms. Some 9% of the variance is associated with joint effect of differences between rooms and student characteristics. In other words, in this sample it is impossible to disentangle a part of the background and room effects.

A second step in the analysis involves substituting measures of teacher behavior which describe the rooms for the dummy variables which simply indicate in which room a student is located. (The number of descriptors should be less than the number of rooms if degrees of freedom are not to be exceeded.) To accomplish this, we used three measures of teacher behavior: carping criticism, teacher warmth and the extent to which the teacher extends freedom and autonomy to the students. Once again, variance partitioning shows that a large amount of the variance in math achievement is associated

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Table II

Partitioning of Variance in Math Achievement into Classroom and Background Related Sources - Year 1

Full Model /model 2.1/		72.98%
Unique to Background /model 2.1 - model 2.3/	57.96%*	
Unique to Classrooms /model 2.1 - model 2.2/	6.14%*	
Overlap	8.88%	

Partitioning of Variance in Math Achievement into Teacher Behavior and Background Related Sources - Year 1

Full Model /model 2.5/		68.74%
Unique to Background /model 2.5 - model 2.4/	65.82%*	
Unique to Teacher Behavior /model 2.5 - model 2.2/	1.90%**	
Overlap	1.02%	

*$p \leq .01$
**$p \leq .05$

with background, over and above the measures of teacher behavior. About 2% is associated with teacher behavior over and above room effects. Only 1% is shared between the two sets of predictors.

By comparing model 2.3 and 2.4 we see that while 15% of the variance in math achievement lies between rooms, only 3% can be attributed to teacher behavior. Either these measures of teacher behavior are not what cause the differences in the outcome--or, the measures of behavior are inadequate. For the moment we can accept either interpretation, for the finding is not as important as the fact that we have outlined an easy way to assess the adequacy of our measures of teacher behavior. Models 2.1 and 2.3 are a standard against which the measures can be evaluated; they require no assumptions about what is being measured on the independent side of the regression equation.

Substantively, we obtain the same kind of results when student satisfaction is used as the dependent variable (Table III). Not much variance is attributable to rooms, fully 30% is explained by the background variables, and there is some, but not much, overlap between rooms and background. Much less of the total variance is attributable to variables in the full model (38% against 73% for math). However, Figure I highlights an important problem: the rooms which had high satisfaction scores are not the same as those which had high math scores. (The rank-order correlation is .1308 ($p > .05$)). It seems probable, then, that activities that might lead to high math scores might not contribute to, or even reduce, satisfaction scores. This observation represents a problem that requires extensive treatment in its own right. For now, we will proceed on the assumption that teachers are willing to maximize one output while perhaps seeking only to

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Table III

Partitioning of Variance in Satisfaction with School into Classroom and Background Related Sources - Year 1

Full Model [model 2.1]		38.44%
Unique to Background [model 2.1 - model 2.3]	30.01%*	
Unique to Classroom [model 2.1 - model 2.2]	6.41%	
Overlap	2.24%	

Partitioning of Variance in Satisfaction with School into Teacher Behavior and Background Related Sources - Year 1

Full Model [model 2.5]		34.49%
Unique to Background [model 2.5 - model 2.4]	25.84%*	
Unique to Teacher Behavior [model 2.5 - model 2.2]	2.24%	
Overlap	6.41%	

*$p \leq .01$

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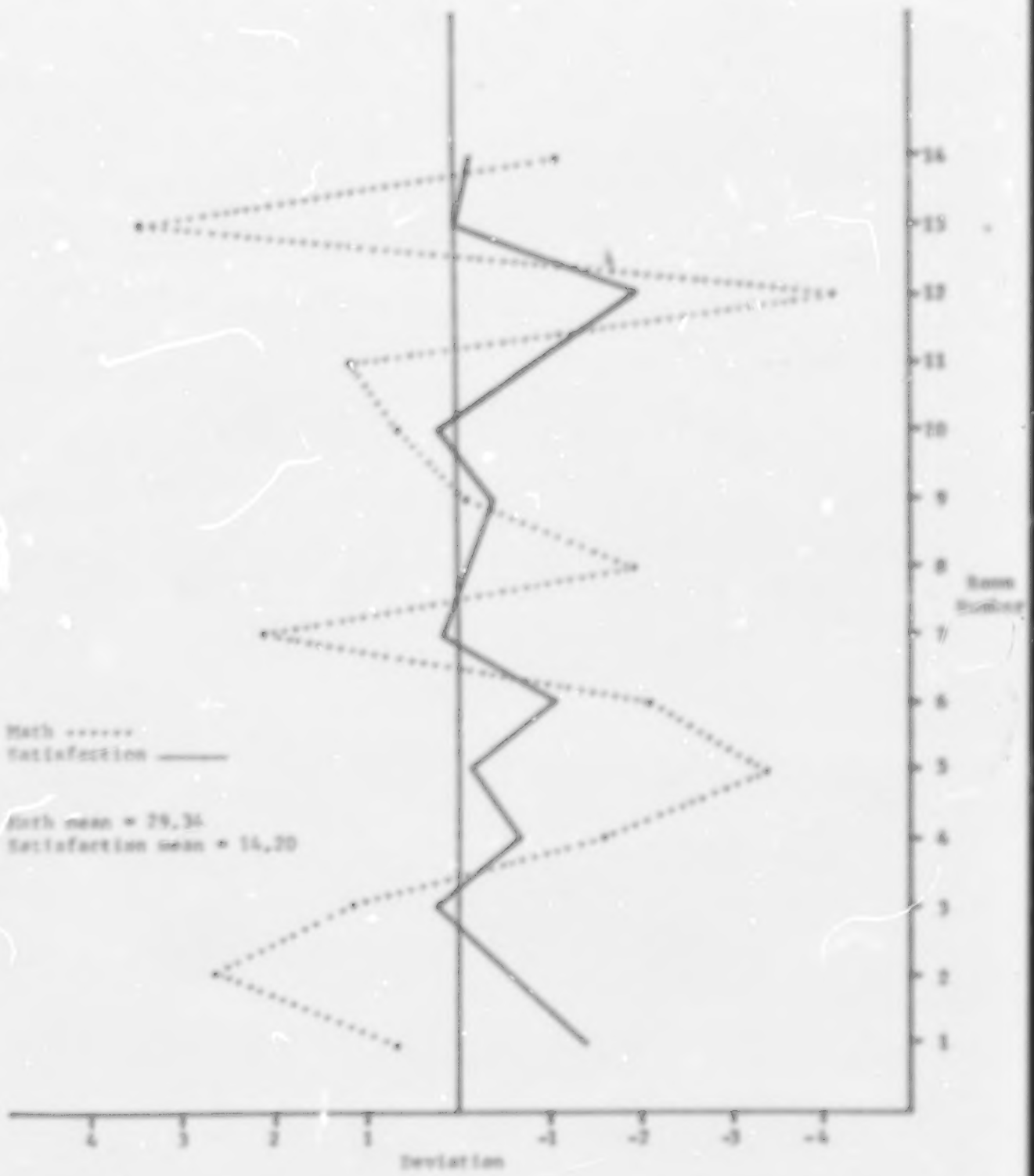

Figure 1
Classroom Deviations from Room Satisfaction and Math Scores - Year 1

avoid serious problems with other outcome(s) that might be considered. In the interest of parsimony we will confine our subsequent analyses to the math outputs.

If the model uncovered by variance partitioning cannot be used on other sets of data, its practical significance is indeed limited. One way to examine the stability of the model is to compare equations derived from a second year of data collected with the same sample of students as they moved into the sixth grade. The relevant second year equations are 3.3, 3.4 and 3.5 in Table IV. These contain information about background, teacher behavior in the second year in all three possible combinations. (Their equivalents are models 2.3, 2.4 and 2.5 from the first year of data.) From a comparison of Tables II and IV it is evident that the results of the variance partitioning (in math achievement) between these two sets of variables does not change substantially from the first year to the second. An F-test of the statistical significance of the difference in the amount of variance attributable to teacher behavior, and the background variables reveal that the differences from year one to year two are not statistically significant at the .05 level. (See Table VI.)

Conclusion from the Variance Partitioning

From all of the above it seems that teacher behavior, as measured in this study, has a trivial effect on both math achievement and satisfaction with school. Moreover, it does not seem likely that any measure of the classroom environment can account for more than 1% of the variance in math achievement nor 8% of the variance in satisfaction with school.

Table 19

Participation of Workers in Work Activeness
and Classroom and Background Related
Factors - Case 2

Full model [illegible] 95.00

Unique to background [illegible] - model 1.3 98.88.00*

Unique to Classroom [illegible] - model 1.3 8.8.00*

Overlap 5.5.00

Participation of Workers in Work Activeness
and Teacher Behavior and Background
Related Factors - Case 2

Full Model [illegible] 80.00

Unique to background [illegible] - model 1.3 60.0.00*

Unique to Teacher behavior [illegible] - model 1.3 5.5.00*

Overlap [illegible]

*P< .01

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[redacted]

[redacted]

Table 4.

[illegible]

[illegible]

	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table IX

Regression Models Predicting Level of Math Achievement - Year 2
N=187

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Variables	Model 3.1 B	Model 3.2 B	Model 3.3 B	Model 3.4 B	Model 3.5 B
Math Achievement Pre-test	.54	.53			.55
Race	-2.64	-1.70			-2.06
Sex	.40	.60			.38
Siblings	-.17	-.22			-.23
IQ Score	.05	.04			.04
Finance	.19	-.05			-.11
Teacher Behavior - Carping Criticism				.14	.52
Teacher Behavior - Warmth				.26	1.04
Teacher Behavior - Autonomy				1.70	.11
Classroom 1	-.59		1.21		
Classroom 2	-2.19		-1.25		
Classroom 3	-2.07		.24		
Classroom 4	-2.33		-.55		
Classroom 5	-.20		-2.56		
Classroom 6	1.24		.27		
Classroom 7	-2.02		.41		
Classroom 8	-.81		-.54		
Classroom 9	.00		2.14		
Classroom 10	1.00		1.91		
Classroom 11	.92		-1.30		
Classroom 12	2.34		2.34		
Classroom 13	.37		4.39		
Classroom 14	.12		.97		
Constant	10.95	11.77	30.61	13.59	-22.31
RSQ	.70	.61	.12	.04	.66

Table X

Regression Models Predicting Level of Satisfaction with School - Year 2
N=187

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Variables	Model 3.1 B	Model 3.2 B	Model 3.3 B	Model 3.4 B	Model 3.5 B
Satisfaction with School Pre-test	.39	.40			.38
Race	-.29	-.62			.05
Sex	.28	.33			.27
Siblings	.03	.03			.01
IQ Score	.03	.03			.04
Finance	.23	.29			.23
Teacher Behavior - Carping Criticism				-.05	.00
Teacher Behavior - Warmth				.38	.44
Teacher Behavior - Autonomy				.64	.36
Classroom 1	-2.09		-2.31		
Classroom 2	-.69		-1.20		
Classroom 3	-.07		-.64		
Classroom 4	-.82		-1.20		
Classroom 5	-.39		-1.27		
Classroom 6	.40		-.37		
Classroom 7	-.29		-.43		
Classroom 8	.53		.16		
Classroom 9	.42		.16		
Classroom 10	.65		.29		
Classroom 11	-1.26		-2.73		
Classroom 12	.27		-1.04		
Classroom 13	-.03		.00		
Classroom 14	.40		.00		
Constant	4.27	4.55	14.64	5.39	-5.82
RSQ	.35	.24	.15	.11	.32

direction. The most noticeable changes, however, have occurred, in the parameters associated with the three dimensions of teacher behavior; the size and direction of the B weights have changed substantially for all three measures.

We applied a test (Huang, 1970) of the constancy of a subset of regression coefficients (B weights) to the measures of teacher behavior predicting math achievement. We rejected the null hypothesis (H_0: $B_1=B_2$) at the .01 level of significance ($F = 9.68$, d.f. = 3,354). We applied the same test to the background variables; the null hypothesis (H_0: $B_1=B_2$) could not be rejected ($F = 1.3363$, d.f. = 6,354).

In summary, the B weights for teacher behavior changed significantly over the period in question. The background measures, on the other hand, behaved consistently over the two samples. We acknowledge that our interpretation of these F statistics is suspect--the measurement instruments are relatively unsophisticated, making it extremely difficult to determine whether the change (and stability) we have verified statistically are, in fact, spurious. Regardless, we feel that the value of the procedure is that it forces educational researchers to consider the issue of the stability of their proposed models.

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